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Site-to-Site Variation in Performance of Dispersion Parameter Estimation Schemes

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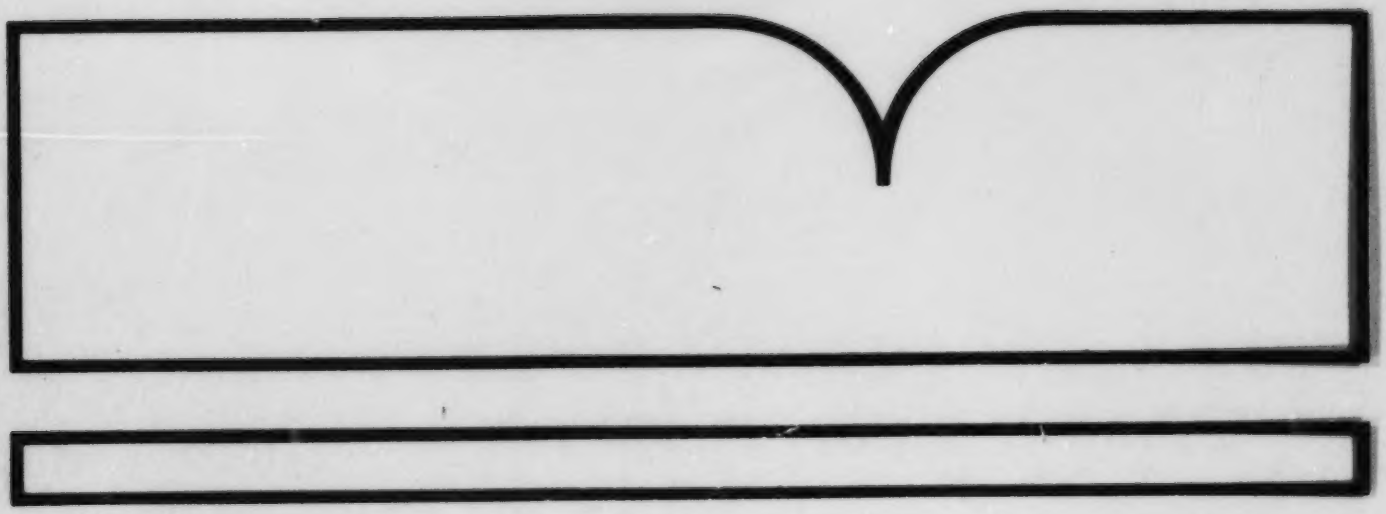

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SITE-TO-SITE VARIATION IN PERFORMANCE OF DISPERSION PARAMETER ESTIMATION SCHEMES

by

John S. Irwin
Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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16. ABSTRACT

The lateral and vertical Gaussian plume dispersion parameters are estimated and compared with dispersion parameters determined for field tracer experiments conducted at 11 sites. The dispersion parameter schemes used in this analysis include Cramer's suggested for tall stack dispersion estimates, Draxler's, suggested for elevated and surface releases, and Pasquill's, suggested for interim use in dispersion estimates. These schemes estimate the dispersion parameters using on-site measurements of the vertical and lateral wind-velocity variances at the effective release height. Tables are presented summarizing the site-to-site variation in the performance of the schemes in estimating the derived dispersion parameters from the tracer experiments. The results suggest that the site-to-site variation in the performance of the schemes is in part related to the averaging time and sampling duration associated with the wind-velocity variances used in estimating the dispersion parameters.

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John S. Irwin*

Environmental Sciences Research Laboratory, EPA,
Research Triangle Park, N.C. 27711

INTRODUCTION

To promote better practices in air pollution modeling, the American Meteorological Society sponsored a workshop on stability classification schemes and sigma curves (Hanna et al., 1977). The participants at this workshop reviewed the bases and limitations of the popular dispersion parameter schemes and suggested that the standard deviation of the crosswind concentration distribution, σ_y, might be viewed as

$$\sigma_y = \sigma_v \, t \, f_y, \qquad (1)$$

where σ_v is the standard deviation of the horizontal crosswind component of the wind, t is the downstream travel time and f_y is a nondimensional function. The standard deviation of the vertical concentration distribution, σ_z, was viewed as

$$\sigma_z = \sigma_w \, t \, f_z, \qquad (2)$$

where σ_w is the standard deviation of the vertical component of the wind, and f_z is a nondimensional function. Small-angle approximations, such as $\sigma_v \, t = \sigma_a \, X$ and $\sigma_w \, t = \sigma_e \, X$ (where σ_a is the standard deviation of the horizontal wind angle, σ_e is the standard deviation of the vertical wind angle, and $X = u \, t$), allow restatement of (1) and (2) in various forms.

*On assignment from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Initial evaluations of some of the currently available schemes for estimating plume dispersion parameters using (1) and (2) revealed variations in the performance of the schemes from one field experiment to the next, for both the lateral and vertical dispersion parameter comparisons (Irwin, MS). Doran et al. (1978) showed that f_y should be a function of the averaging time, s; the sampling duration, τ, associated with σ_y; and the sampling duration, T, associated with σ_y. In most experiments, the variance of the wind direction is measured during the duration of the tracer measurements, and T equals τ. The Doran et al. (1978) results suggest that the variations in performance of dispersion parameter estimation schemes from site-to-site are in part related to variations in s, τ, and T. The primary purpose of this analysis is to summarize the site-to-site variations in the performance of several dispersion parameter estimation schemes, including schemes presented by Cramer (1976), Draxler (1976), and Pasquill (1976). The secondary purpose of this analysis is to indicate values of s, τ, and T to associate with the dispersion parameter schemes tested, given the available data.

TABLE 1. Dispersion experiments having near-surface release heights.

Site	Release Height (m)	Receptor Height (m)	Meteorological data	Dispersion data, tracer
Round Hill I (Cramer, Record, and Vaughan, 1958)	0.3	2.0	U, σ_a, σ_e at 2 m ΔT (12 - 1.5 m)	Concentrations along arcs (50, 100, 200 m), 10-min releases, SO_2 gas.
Round Hill II (Cramer, Record, and Vaughan, 1958)	0.5	1.5	U, σ_a at 2 m ΔT (12 - 1.5 m)	Concentrations along arcs (50, 100, 200 m), 10-min releases, SO_2 gas.
Prairie Grass (Barad, 1958) (Haugen, 1959)	0.46	1.5	U, σ_a, σ_e at 2 m ΔT (16 - 2 m)	Concentrations along arcs (50, 100, 200, 400, 800 m), 10 min-releases, SO_2 gas.
N.R.T.S. A&B (Islitzer and Dumbauld, 1963)	~1.0	~1.0	U, σ_a, σ_e at 4 m ΔT (16 - 4 m) ΔT (8 - 1 m)	σ_y and max (100, 200, 400, 800, 1600, 3200 m), 60-min releases, uranine dye.
Green Glow (Fuquay, Simpson, and Hinds, 1964)	2.5	1.5	U, σ_a at 2.1 m Ri (15.2 - 2.1 m)	σ_y (200, 800, 1600, 3200, 12800, 25600 m), 30-min releases, zinc sulfide.
Hanford-30 (Fuquay, Simpson, and Hinds, 1964)	2.5	1.5	U, σ_a at 2.1 m Ri (15.2 - 2.1 m)	σ_y (200, 800, 1600, 3200, 12800 m), 60-min releases, zinc sulfide.
Ocean Breeze (Haugen and Fuquay, 1963)	2 to 3	1.5	U, σ_a at 3.7 m ΔT (16.5 - 1.8 m)	σ_y (1200, 2400, 4800 m) 30-min releases, zinc zinc sulfide.
Dry Gulch (Haugen and Fuquay, 1963)	2 to 3	1.5	U, σ_a at 3.7 m ΔT (16.5 - 1.8 m)	σ_y (853, 1500, 2301, 4715, 5665 m), 30-min releases, zinc sulfide.
Mountain Iron (Hinds and Nickola 1967, Hinds, 1968)	~2.0	1.5	U, σ_a at 3.66 m ΔT (18 - 1.8 m) ΔT (91.4 - 1.8 m)	σ_y (variable, from 260 m to 11400 m) Several 5-min releases, mostly 30 min releases, zinc sulfide.
Hanford-67 (Nickola, 1977)	2.0	1.5	U at 2 m σ_a at 1.5 m ΔT (15.2 - 0.9 m)	σ_y (200, 400, 800, 1200, 1600, 3200, 5000, 7000, 12800 m), 10-to 30-min releases, zinc sulfide, fluoresein (uranine), rhodamine B, krypton-85.

EXPERIMENTAL APPROACH

Tables 1 and 2 summarize the field data used in this analysis. Included in these tables are the sources of the data and a summary of the meteorological and dispersion data available. The details of converting the field data to a similar format are summarized in Irwin (MS). Table 3 summarizes the s and τ associated with the wind turbulence measurements, the T associated with the concentration measurements (and hence with σ_y and σ_z), and the aerodynamic roughness length for each of the field experiments.

The vertical and lateral dispersion parameters were estimated using (1) and (2) for each downwind arc for the models listed in Table 4. Model 1 is Draxler's (1976), and model 2 is Cramer's (1976). Models 3 and 4 are variations of models 1 and 2 in which f_y and f_z do not vary with release height. Model 5 is Pasquill's (1976). For these estimates, the vertical and lateral velocity variances at release height were used.

TABLE 2. Dispersion experiments having elevated release heights.

Site	Release Height (m)	Receptor Height (m)	Meteorological data	Dispersion data, tracer
Suffield (Walker, 1965)	7.42 and 15	Surface	U, σ_a, σ_e at 8 m and 16 m; ΔT (4 - 0.5 m)	σ_y (27.4 to 1097.3 m); 30-to 60-min releases, glass spheres
NRTS (Islitzer, 1961) (Bowne, 1960)	46	1	U, σ_a, σ_e at 43 m; T (43 - 3 m)	Sutton (n, C_y, C_z) (150 to 3400 m), 30-min releases, uranine dye
Hanford-67 (Nickola, 1977)	26 and 56	1.5	U, σ_a at 26 and 56 m; ΔT (15.2 - 0.9 m)	σ_y (200 to 4000 m), 10-to 30-min releases, zinc sulfide, fluorescent (uranine), rhodamine B, krypton-85
Ågesta (Högström, 1964)	50	Smoke puff photography	σ_e estimates at 50 m; Diffusion time; Stability parameter	σ_z (100 to 1500 m); σ_z (20 to 400 s); (Sampling time about 60 min)
Hanford (Elderkin et al. 1963) and (Hilst and Simpson, 1958)	56	1.5 for σ_y; Vertical array about release height for σ_z	U, σ_a at 61 m; Ri (76 - 15 m) for σ_y; ΔT (91 - 30 m) for σ_z	σ_y (100 to 1600 m); σ_z (152 to 1524 m); 15-to 60-min releases, flourescent dye
Karlsruhe (Thomas et al., 1976) (Thomas and Nester, 1976)	100	Surface	U, σ_a, σ_e at 100 m; ΔT (100 - 30 m)	σ_y and σ_z (variable 100 to 3900 m), 20-to 60-min releases, tritiated water vapor, halogenated hydrocarbons
Porton (Hay and Pasquill, 1957)	140 to 255	Vertical array about release height	U, σ_e at release height; ΔT (7 - 1.2 m)	σ_z (variable 100 m to 500 m), 30-min releases, lycopodium spores

Various statistics comparing the estimated dispersion parameters with measured values initially were computed for each possible combination of release height (elevated and near-surface) and for stable and unstable stratification. The fractional error was found to be a useful statistic, as it best summarized, in a quantitative sense, the subjective impressions of model bias and precision of model estimates gained from these analyses. The fractional error

$$e = 2 (P - O) / (P + O), \qquad (3)$$

where P is the model estimate and O is the measured value, has the same numerical value, but different signs, for either an overestimate of n times the measured value or an underestimate of 1/n times the measured value.

TABLE 3. Concentration sampling durations, wind-velocity variance averaging times and sampling durations, and site roughness lengths for the tracer experiments.

	Site roughness (cm)	Concentration sampling duration (min)	Lateral wind fluctuations		Vertical wind fluctuations	
			Averaging time (s)	Sampling duration (min)	Averaging time (s)	Sampling duration (min)
Near-surface releases						
Round Hill I	>10	10	1.0[k]	10	1.0	10
Round Hill II	>10	10	2.5	10	n/a	n/a
Prairie Grass	0.6-0.9[a]	10	2.5	10	1.067	10
NRTS A&B	1.5	60	5.0	60	5.0	60
Green Glow	3.0	30	20	30	n/a	n/a
Hanford-30	3.0	20 to 75	20	20 to 75[o]	n/a	n/a
Ocean Breeze	[b]	30	2.0[m]	47	n/a	n/a
Dry Gulch	[b]	30	2.0[m]	47	n/a	n/a
Mountain Iron	[c]	5 to 48[h]	10	5 to 48	n/a	n/a
Hanford-67(2m)	3.0	30	5.0	30	n/a	n/a
Elevated releases						
Suffield	2.0[d]	30 to 60	1.0	30 to 60[p]	n/a	n/a
NRTS	1.5[e]	30	5.0	30	5.0	30
Hanford-67(26, 56m)	3.0	30	5.0	30	n/a	n/a
Agesta	60	60	n/a	n/a	[s]	60
Hanford	3-5[f]	[i]	5.0	15 to 60[r]	[s]	Unk
Karlsruhe	110	30	Unk[n]	10	Unk.	10
Porton	5.0[g]	30	n/a	n/a	2.5	30

n/a = not applicable, Unk = unknown

[a] Högström (1964) suggests 0.9 cm and Horst et al. (1979) suggest 0.6 cm.

[b] Horst et al. (1979). Rolling sand dunes covered with dense palmetto and brushwood (OB). Sloping mesa cut by deep ravines, vegetation mainly grasses with occasional brush and tree lines (DG).

[c] Mountainous terrain in Southern California.

[d] Estimated from site descriptions.

[e] Assuming value suggested by Islitzer and Dumbauld (1963) for the NRTS A&B experiments.

[f] Högström (1964) suggests 5 cm and Horst et al. (1979) suggest 3 cm.

[g] Högström (1964).

[h] 17 cases (5 min), 24 cases (15 to 20 min), 67 cases (25 to 30 min), and 3 cases (44 to 48 min).

[i] None reported; sampling apparently continued as long as conditions were steady-state.

[k] Assuming "movie camera" procedure used in 1952 was also used in 1954-55, Cramer and Record (1953).

[m] Horst et al. (1979) report questionable wind-vane performance occurred that may have led to erroneously high values for the lateral wind fluctuations.

[n] Thomas et al. (1979). Data collected continuously by an automatic data acquisiton system. No information given on sampling rate or averaging time used.

[o] 7 cases (20 to 21 min), 68 cases (30 to 31 min), 10 cases (45 to 51 min), and 28 cases (60 to 75 min).

[p] 32 cases (30 min), 27 cases (44 to 49 min), and 45 cases (56 to 60 min).

[r] Duration for each trial not given.

[s] Velocity variances estimated from dispersion data.

TABLE 4. Equation used for the functions f_y and f_z to characterize the growth of lateral and vertical dispersion as a function of travel time, T (in seconds), or of downwind distance, X (in meters). Model 1 is Draxler's (1976) and provides for variation of the functions with release height and stability. Model 2 is Cramer's (1976), where no buoyancy-induced dispersion is assumed. Model 5 is Pasquill's (1976).

	Lateral dispersion		Vertical dispersion	
Model 1	Elevated releases		Elevated releases	
		$1/f_y = 1 + 0.9(T/1000)^{0.5}$	unstable	$1/f_z = 1 + 0.9(T/500)^{0.5}$
			stable	$1/f_z = 1 + 0.945(T/100)^{0.806}$
	Surface releases		Surface releases	
	unstable	$1/f_y = 1 + 0.9(T/300)^{0.5}$	unstable	$f_z = (0.3/0.16)(T/100-0.4)^2 + 0.7$
	stable	$1/f_y = \begin{cases} 1 + 0.9(T/300)^{0.5} & T<550 \\ 1 + 28/(T)^{0.5} & T>550 \end{cases}$	stable	$1/f_z = 1 + 0.9(T/50)^{0.5}$
Model 2		$f_y = (50/X)[(X-5)/45]^{0.9}$		$f_z = 1$
Model 3		$1/f_y = 1 + 0.9(T/1000)^{0.5}$	unstable	$f_z = 1$
			stable	$1/f_z = 1 + 0.9(T/50)^{0.5}$
Model 4		$1/f_y = 1 + 0.9(T/1000)^{0.5}$	unstable	$1/f_z = 1 + 0.9(T/500)^{0.5}$
			stable	$1/f_z = 1 + 0.9(T/50)^{0.5}$
Model 5		$1/f_y = \begin{cases} 1 + (X/2500)^{0.5} & X<10{,}000 \\ 3\,(X/10{,}000)^{0.5} & X>10{,}000 \end{cases}$		Pasquill-Gifford dispersion scheme

Those cases with downwind travel distances greater than 5.4 km were excluded from analysis. This only involved removing some of the lateral dispersion parameter comparisons, as all the vertical dispersion comparisons were within 5.4 km. The measurements of the lateral dispersion at distances beyond 5.4 km were considered most suspect, due to limitations in the design of the field experiments. Restricting the analysis to distances less than 5.4 km would result in negligible contributions to the lateral dispersion due to wind direction shear in the vertical. Of the schemes tested, Cramer's (1976) and Draxler's (1976) characterizations of f_y implicitly account for the effects of wind-direction shear in the vertical on σ_y. Pasquill's (1976) characterization of the lateral dispersion accounts for the effects of wind-direction shear on σ_y separately from f_y. By limiting the downwind distances employed in this analysis, the lateral dispersion parameter schemes are on a more equal basis for comparison.

ANALYSIS

Lateral Dispersion

The values of the median of the residuals presented in Table 5 for the σ_y comparisons suggest that models 1, 3, 4, and 5 have a bias to underestimate σ_y, while model 2 tends to overestimate σ_y.

In Table 6, the mean and the standard deviation of the fractional errors (in percent) and the percent of the model estimates within a factor of two of the measured values are given for each model in each field experiment.

No trend, as a function of concentration sampling duration, could be seen in the variation of the performance of the models in estimating the lateral dispersion parameters.

The trend towards underestimates of the lateral dispersion parameters as averaging time increases is what would be expected, but the scatter and uncertainty of the results, allow only qualitative judgements to be made. This tendency towards smaller estimates of σ_y as s increases is due to a reduction in the computed

TABLE 5. Lateral dispersion parameter estimates compared with the measured values. The three statistics listed for each are the mean, the median, and the standard deviation of the residuals (estimated values minus measured values) in meters. N is the number of cases. Values less than ± 0.5 are shown as ± 0.

	N	Model 1	Model 2	Model 3 Model 4	Model 5
Stable stratification					
Near-surface releases					
Round Hill I	45	-0, +0, 6	4, 3, 7	2, 1, 6	2, 1, 6
Round Hill II[a]	18	5, 4, 4	10, 8, 8	7, 6, 6	7, 5, 6
Prairie Grass	160	-9, 1, 69	-1, 3, 67	-5, 2, 68	-6, 1, 67
NRTS A&B	35	-3, -4, 32	26, +0, 56	11, -2, 40	-1, -3, 30
Green Glow	60	-41, -23, 84	-5, -0, 81	-36, -10, 83	-44, -17, 84
Hanford-30	75	-55, -23, 108	-6, 2, 98	-58, -11, 121	-61, -15, 118
Ocean Breeze[a,b]	50	83, 50, 120	158, 121, 115	67, 61, 80	59, 59, 72
Dry Gulch[a,b]	17	116, 86, 250	212, 193, 271	97, 72, 209	80, 67, 203
Mountain Iron[b]	19	-45, -25, 85	11, 17, 71	-51, -25, 93	-68, -29, 103
Hanford-67(2m)	87	1, -8, 114	72, 30, 144	-5, -4, 76	-9, -4, 84
Elevated releases					
Suffield	55	-1, +0, 20	1, 1, 21	-1, +0, 20	-2, -0, 21
Hanford-67(26, 56m)	208	-31, -22, 69	-6, -9, 76	-31, -22, 69	-51, -37, 67
Karlsruhe[c]	6	-528, -516, 420	-516, -510, 410	-528, -516, 420	-541, -526, 429
Unstable stratification					
Near-surface releases					
Round Hill I	27	-4, -1, 10	2, 2, 9	-1, 1, 10	-3, -1, 9
Round Hill II[a]	12	-1, -1, 3	6, 4, 4	2, 1, 3	+0, -0, 3
Prairie Grass	155	-8, -3, 19	4, 1, 22	-1, -1, 20	-6, -3, 19
NRTS A&B	93	-6, -5, 50	37, 4, 76	22, +0, 59	-10, -5, 49
Hanford-30	38	-39, -20, 75	24, 7, 65	-7, 2, 62	-28, -7, 70
Ocean Breeze[a,b]	122	28, 32, 70	193, 159, 117	101, 87, 77	72, 63, 65
Dry Gulch[a,b]	190	7, 8, 125	202, 162, 181	86, 61, 136	65, 46, 115
Mountain Iron[b]	92	-42, -25, 139	105, 44, 220	22, 9, 164	-7, -8, 146
Hanford-67(2m)[c]	7	11, 10, 7	74, 49, 59	45, 31, 32	18, 17, 11
Elevated releases					
Suffield	49	-3, 1, 24	1, 2, 22	-3, 1, 24	-9, -1, 28
NRTS	96	-7, -4, 42	7, -1, 55	-7, -4, 42	-34, -14, 50
Hanford-67(26, 56m)	46	-11, -8, 41	24, 8, 59	-11, -8, 41	-40, -34, 46
Hanford	57	-13, -11, 32	+0, -2, 38	-13, -11, 32	-28, -22, 34
Karlsruhe	33	-129, -52, 204	-115, -36, 193	-129, -52, 204	-145, -74, 202

[a] Lateral turbulence measurements questionable.
[b] Complex terrain.
[c] Fewer than 10 cases.

values of σ_a as s increases. As discussed in Pasquill (1974), the effect of s on the computed variance is to smooth out the fine structure of the velocity variations. The contributions to the total variance becomes very small for fluctuations of frequency n > 1/s.

As site roughness increases, the frequency spectrum of wind-velocity fluctuations is expected to reflect an increase in the small-scale mechanical turbulence. Such an increase would be most noticeable for measurements near the surface during stable stratification. All other factors being equal, it is anticipated that the effects of s on the computed values of σ_a, and hence on the estimates of σ_v, may be more dramatic at sites having large surface roughness compared to the effects seen at sites having small surface

TABLE 6. Lateral dispersion parameter estimates compared with the measured values. The three statistics listed for each are the mean fractional error (percent), the standard deviation of the fractional errors (percent), and the percent of the estimates within a factor of two of the measured values. N is the number of cases.

	N	Model 1	Model 2	Model 3 Model 4	Model 5
Stable stratification					
Near-surface releases					
Round Hill I	45	-4, 35, 91	22, 35, 91	8, 35, 93	7, 34, 93
Round Hill II[a]	18	30, 21, 94	54, 23, 72	42, 22, 83	40, 22, 83
Prairie Grass	160	-4, 56, 85	21, 58, 74	9, 58, 80	4, 55, 82
NRTS A&B	35	-13, 36, 94	16, 39, 86	3, 38, 91	-8, 34, 97
Green Glow	60	-37, 29, 87	-3, 29, 98	-25, 31, 87	-32, 28, 87
Hanford-30	75	-32, 32, 92	4, 31, 93	-22, 33, 91	-25, 31, 89
Ocean Breeze[a,b]	50	42, 42, 64	73, 36, 38	44, 41, 62	41, 39, 74
Dry Gulch[a,b]	17	48, 48, 76	79, 46, 41	55, 53, 53	48, 53, 59
Mountain Iron[b]	19	-23, 29, *	12, 23, *	18, 22, *	28, 23, 89
Hanford-67(2m)	87	-12, 37, 93	26, 35, 86	-2, 36, 92	-4, 36, 92
Elevated releases					
Suffield	55	-2, 41, 85	7, 42, 84	-2, 41, 85	-8, 42, 87
Hanford-67(26, 56m)	208	-26, 41, 84	-11, 41, 88	-26, 41, 84	-42, 39, 75
Karlsruhe[c]	6	-161, 11, 0	-155, 13, 0	-161, 13, 0	-167, 8, 0
Unstable stratification					
Near-surface releases					
Round Hill I	27	-10, 21, *	8, 19, *	-1, 20, *	-8, 19, *
Round Hill II[a]	12	-2, 9, *	18, 9, *	8, 9, *	2, 9, *
Prairie Grass	155	-18, 24, 97	3, 25, 99	-6, 25, 98	-16, 24, 98
NRTS A&B	93	-8, 27, *	15, 29, 92	7, 29, 95	-10, 26, *
Hanford-30	38	-20, 23, 95	17, 23, 97	1, 22, *	-12, 24, 97
Ocean Breeze[a,b]	122	23, 33, 89	74, 28, 41	51, 31, 70	41, 31, 74
Dry Gulch[a,b]	190	7, 41, 89	62, 33, 58	35, 39, 78	28, 34, 85
Mountain Iron[b]	92	-21, 50, 82	28, 52, 75	6, 50, 87	-7, 52, 86
Hanford-67(2m)[c]	7	12, 6, *	52, 11, *	36, 8, *	18, 9, *
Elevated releases					
Suffield	49	4, 20, *	12, 20, *	4, 20, *	-5, 22, 98
NRTS	96	-10, 20, *	-2, 21, *	-10, 20, *	-28, 22, 98
Hanford-67(26, 56m)	46	-6, 13, *	10, 13, *	-6, 13, *	-22, 13, *
Hanford	57	-12, 18, *	-3, 20, *	-12, 18, *	-28, 21, 98
Karlsruhe	33	-47, 56, 64	-38, 54, 67	-47, 56, 64	-60, 50, 58

[a] Lateral turbulence measurements questionable
[b] Complex terrain
[c] Fewer than 10 cases
* All estimates within a factor of two

roughness. Analyses of the results presented in Tables 5 and 6 are not conclusive, as there are so few cases for comparison.

The results having 1-s averaging time seem to be unaltered in going from 2- to 10-cm roughness. It is best not to compare results from surface and elevated releases, as the effects of s on σ_a for the elevated releases would be expected to be less than for a surface releases. However, the elevated releases at 2-cm roughness, with a 1-s averaging time, are the Suffield experiments, which were the lowest of the elevated releases having only 7.4- and 15-m release heights. The comparisons having 5-s averaging times suffer, as there is only a small change in roughness (from 1.5 to 3 cm). From these results, it is not apparent that σ_a is more sensitive to averaging time effects as roughness increases.

Earlier in the discussion, it was mentioned that differences between the sampling durations used to compute σ_v and σ_y might affect the dispersion parameter estimates. Differences between τ and T occured at three of the experiments: Karlsruhe, Ocean Breeze, and Dry Gulch. The effect of differences between τ and T on the σ_y estimates for the Ocean Breeze and Dry Gulch experiments, where τ was 47 min and T was 30 min, could not be computed from the original data listings. The effect of differences in τ and T can be computed for the Karlsruhe experiments. A reanalysis to compute 30-min values of σ_a from the 10-min summary data, indicates that the 30-min values of σ_a are on average 28 % larger than the 10-min values of σ_a used in the original estimates of the lateral dispersion parameters.

Vertical Dispersion

Tables similar to Tables 5 and 6 were developed for the σ_z comparisons. No trends as a function of concentration sampling duration or site roughness length could be seen in the variation of the performance of the models in estimating the vertical disperison paraemters. Excluding those experiments where the wind turbulence was questionable, the terrain was complex, or there were fewer than 10 cases for analysis, shifts in the median of from 3 to -20 m are typical from one field experiment to the next.

There was a strong tendency for model 2 (Cramer, 1976) to overestimate the σ_z values during stable stratification. This was discounted, as it resulted from not including the depth of the nocturnal mixed surface layer in the characterization of the vertical dispersion parameter. Sufficient data, such as detailed profiles of the variance of the vertical velocity fluctuations, were not available for the depth of the nocturnal mixed surface layer to be specified confidently. Limiting of the vertical dispersion during stable stratification is an important consideration in Cramer's model.

The analyses of the mean fractional errors of the vertical dispersion parameter estimates suggest that models 1, 3, and 4 underestimate the σ_z values for the NRTS A&B experiments, Islitzer and Dumbauld (1963), especially for the cases during stable stratification. Whether this is due to the 5-s averaging time or due to some other effect such as deposition is not clear.

CONCLUSIONS

Dispersion parameter estimates were made using 5 models for comparison with parameters determined during 17 field tracer experiments conducted at 11 sites to investigate whether the variations in averaging time, s; the sampling duration, τ, associated with the turbulence measurements; and the sampling duration, T, associated with the dispersion measurements, accounted for observed site-to-site variations in the performance of the schemes as suggested by Doran et al. (1970).

The variation in the performance of the lateral dispersion parameter estimates with respect to s suggest that underestimates of the dispersion parameters occur if the averaging time is too long. The decrease in σ_y is related to the decrease in σ_a as averaging time, s, increases. The variations in performance of the dispersion parameter schemes from one experiment to the next are quite large. In this analysis, it was not clear whether all or most of these variations could be related to variations in s, τ, and T. The relationships between the performance of the dispersion parameter estimation schemes and s, τ, and T may well have been obscured by the fact that the data compared was collected at different sites using different experimental designs. Even with the scatter in the results, it would seem that for the models tested, s should be 5 s or less for the lateral dispersion parameter estimates and perhaps less than 2 s for the vertical dispersion parameter estimates. The underestimates of the lateral dispersion parameters for the Karlsruhe experiments suggest that the sampling duration for the computations of σ_y should be similar to sampling duration associated with the σ_y values. More comparisons are needed in which the values of s, τ, and T are systematically varied to better characterize the sensitivity of the dispersion parameter estimates to s, τ, and T.

REFERENCES

Barad, M. L. Ed., 1958: Project Prairie Grass, a field program in diffusion. Geophysical Research Papers, No. 59, Vols. I and II. Air Force Cambridge Research Center Report AFCRC-TR-58-235, 479 pp. [NTIS PB 151 425 and PB 151 424]

Bowne, N., 1960: Measurements of atmospheric diffusion from an elevated source. Proceedings of 6th A.E.C. Air Cleaning Conference, Atomic Energy Commission, 76-88. [NTIS TID-7593].

Cramer, H. E., 1976: Improved techniques for modeling the dispersion of tall stack plumes. Proceedings of the 7th International Technical Meeting on Air Pollution Modeling and its Application, No. 51, NATO/CCMS, 731-780. [NTIS PB 270 799]

_____, F. A. Record and H. C. Vaughan, 1958: The Study of the Diffusion of Gases of Aerosols in the Lower Atmosphere. AFCRL-TR-58-239, The MIT Press, 133 pp. [NTIS AD 152 582]

_____, and F. A. Record, 1953: The variation with height of the vertical flux of heat and momentum. J. Appl. Meteor., 10, 219-226.

Doran, J. C., T. W. Horst and P. W. Nickola, 1978: Variations in measured values of lateral diffusion parameters. J. Appl. Meteor., 17, 825-831.

Draxler, R. R., 1976: Determination of atmospheric diffusion parameters. Atmos. Environ., 10, 99-105.

Elderkin, C. E., W. T. Hinds and N. E. Nutley, 1963: Dispersion from elevated sources. Hanford Radiological Sciences Research and Development Annual Report for 1963, 1.29-1.36. [NTIS HW-81746]

Fuquay, J. J., C. L. Simpson, and W. T. Hinds, 1964: Prediction of environmental exposures from sources near the ground based on Hanford experimental data. J. Appl. Meteor., 3, 761-770

Hanna, S. R., G. A. Briggs, J. Deardorff, B. A. Egan, F. A. Gifford, and F. Pasquill, 1977: AMS-workshop on stability classification schemes and sigma curves - summary of recommendations. Bull. Amer. Meteor. Soc., 58, 1305-1309

Haugen, D. A. Ed., 1959: Project Prairie Grass, a field program in diffusion. Geophysical Research Papers. No. 59, Vol. III. Air Force Cambridge Research Center Report AFCRC-TR-58-235, 673 pp. [NTIS PB 161 101]

_____, and J. J. Fuquay, Eds., 1963: The Ocean Breeze and Dry Gulch diffusion programs, Vol. I. Air Force Cambridge Research Laboratories and Hanford Atomic Products Operations, Report HW-78435, 240 pp. [Available from Technical Information Center, P.O. Box 62, Oak Ridge, TN]

Hay, J. S., and F. Pasquill, 1957: Diffusion from a fixed source at a height of a few hundred feet in the atmosphere. J. Fluid Mech., 2, 299-310

Hilst, G. R., and C. L. Simpson, 1958: Observations of vertical diffusion rates in stable atmospheres. J. Meteor., 15, 125-126

Hinds, W. T., 1968: Diffusion over coastal mountains of Southern California. Pacific Northwest Laboratories Annual Report for 1967, Vol. II: Physical Sciences, Part 3. Atmospheric Sciences, D. W. Pearce, Ed., Pacific Northwest Laboratories Report BNWL-715-3, 19-53. [NTIS BNWL 7-5-3]

_____, and P. W. Nickola, 1967: The Mountain Iron diffusion program: Phase I, South Vandenberg, Vol. I, Pacific Northwest Laboratories Report BNWL-572, 220 pp. [NTIS AD 721 858]

Högström, U., 1964: An experimental study on atmospheric diffusion Tellus., 16, 205-251

Horst, T. W., J. C. Doran, and P. W. Nickola, 1979: Evaluation of empirical atmospheric diffusion data. Pacific Northwest Laboratories Report NUREG/CR-0798, 137 pp. [NTIS PNL-2599]

Irwin, J. S., (MS): Estimating plume dispersion - a comparison of several sigma schemes.

Islitzer, N. F., 1961: Short-range atmospheric dispersion measurements from an elevated source. J. Meteor., 18, 443-450.

_____, and R. K. Dumbauld, 1963: Atmospheric diffusion-deposition studies over flat terrain. Int. J. Air Water Pollut., 7, 999-1022.

Nickola, P. W., 1977: The Hanford 67-series: a volume of atmospheric field diffusion measurements. Battelle Pacific Northwest Laboratories, 454 pp. [NTIS PNL-2433]

Pasquill, F., 1974: Atmospheric Diffusion. John Wiley & Sons, 429 pp.

_____, 1976: Atmospheric dispersion parameters in Gaussian plume modeling, Part II: possible requirements for change in the Turner workbook values. U.S. Environmental Protection Agency Report EPA-600/4-76-030b, 53 pp. [NTIS PB 258 036]

Thomas, P. W., W. Hubschmann, L. A. Konig, H. Schuttelkopf, S. Vogt and M. Winter, 1976: Experimental determination of the atmospheric dispersion parameters over rough terrain, Part I: measurements at the Karlsruhe Nuclear Research Center. Federal Republic of Germany, Central Division for Nuclear Research, M.B.H., Report KFK2285, 132 pp.

_____, and K. Nester, 1976: Experimental determination of the atmospheric dispersion parameters over rough terrain, Part II: evaluation of measurements. Federal Republic of Germany, Central Division for Nuclear Research, M.B.H., Report KFK2286, 116 pp.

Walker, E. R., 1965: A particulate diffusion experiment. J. Appl. Meteor., 4, 614-621.